OVERVIEW OF THE CrIS SDR: S-NPP AND NOAA-20

Flavio Iturbide-Sanchez, NOAA/NESDIS/STAR
CrIS SDR Team Lead
On behalf of the CrIS SDR Team

Outline

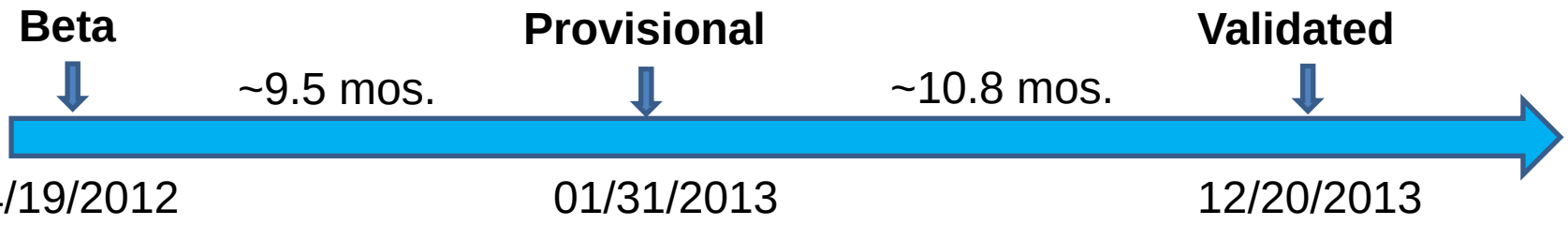
- Cal/Val Team Members
- Sensor/Algorithm Overview
- S-NPP/N-20 CrIS SDR Performance
- Major Risks/Issues and Mitigation
- Milestones and Deliverables
- Future Plans/Improvements
- Summary

Team Members

PI	Organization
Flavio Iturbide-Sanchez	NOAA/STAR (Contractors: Yong Chen, Denis Tremblay, Likun Wang and Adrew Wald)
Dave Tobin	U. of Wisconsin (UW)
Larrabee Strow	U. of Maryland Baltimore County (UMBC)
Deron Scott	Space Dynamics Lab (SDL)
Dan Mooney	MIT/LL
Dave Johnson	NASA Langley
Lawrence Suwinski	Harris
Joe Predina	Logistikos
Deirdre Bolen	JPSS/JAM

CrIS SDR Maturity Level Timeline

S-NPP CrIS SDR

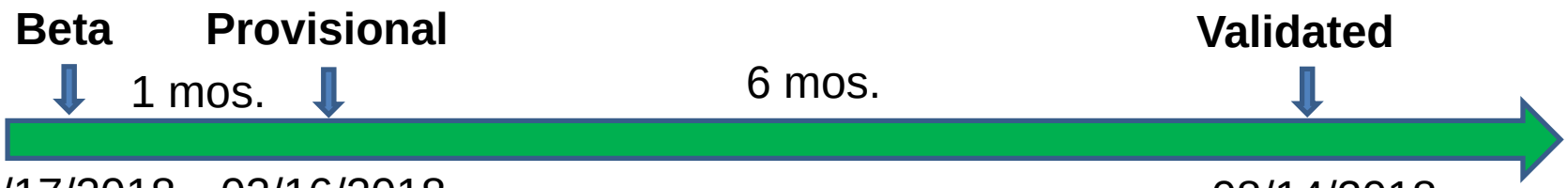


04/19/2012 01/31/2013 12/20/2013

S-NPP Launch:10/28/2011.
First Science Data:01/18/2012.
Transition to FSR mode:12/04/2014

~20 mos.

NOAA-20 CrIS SDR



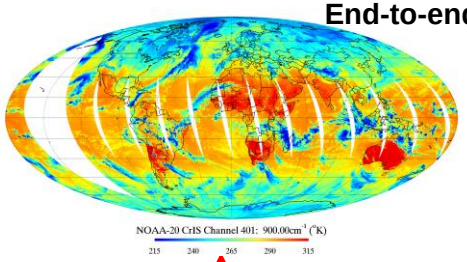
01/17/2018 02/16/2018 08/14/2018
Expected Effective Date

NOAA-20 Launch:11/18/2017
First Science Data:01/04/2018

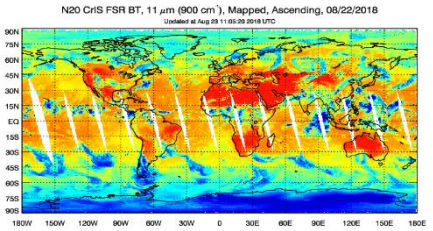
7 mos.

NOAA-20 CrIS Major Events and Milestones

End-to-end System (Flight/Ground) demonstration



Optimally Calibrated and Validated Observations



1/5/2018
FIRST LIGHT
GLOBAL IMAGES

1/17/2018
BETA MATURITY
ENGPKT V113

2/16/2018
PROVISIONAL MATURITY
ENGPKT V114

3/5/2018
IDPS BLOCK 2.1 MX0
DR 8399: CRIS ICT PRT3, TELEMETRY

4/30/2018
IDPS BLOCK 2.1 MX1
DR 8444: USING EXTENDED INTERFEROGRAMS
DR 8361: ENGPKT OUTPUT FREQUENCY
DR 8445: FSR LONGWAVE RADIANCE ANOMALY (FOLDING INDEX)

5/24/2018
DR 8653: N-20 SDR ANOMALIES
RELATED TO MISSING RDR PACKETS

7/2/2018
IDPS BLOCK 2.1 MX2
DR 8489: MISSING DS CAL PACKETS
DR 8490: OVERALL QUALITY FLAG FOR NAN
DR 8491: METROLOGY LASER WAVELENGTH AS NAN

8/14/2018
VALIDATED MATURITY
ENGPKT V115

2/2/2018 - 2/16/2018
BIAS TILTS ANOMALY

7/19/2018 - 7/26/2018
BIAS TILTS ANOMALY

11/18/2017 - 1/3/2018
OUTGASSING PHASE

1/4/2018 - 1/17/2018
EARLY CHECK

1/17/2018 - 2/16/2018
INTENSIVE CAL/VAL

2/16/2018 - 8/14/2018
CONTINUING INTENSIVE CAL/VAL

1/1/2018

18 November 2017

14 August 2018

Planned Improvements

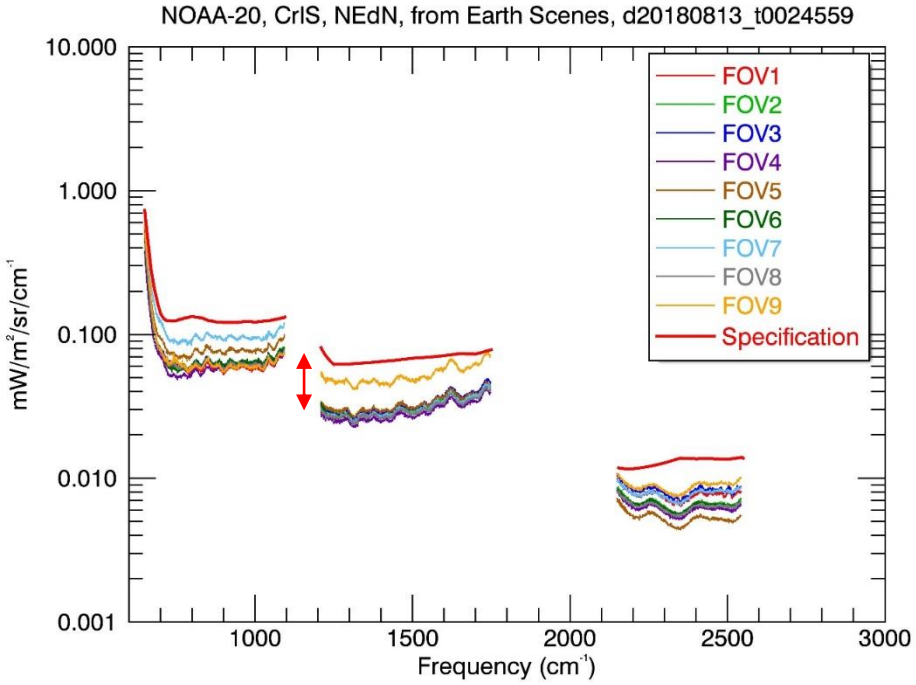
9/24/2018
IDPS BLOCK 2.1 MX3
DR 8013: CRIS INTERFEROGRAMS SPIKES DETECTION AND CORRECTION
DR 8629: N-20 SWEEP DIRECTION INDICATORS AND QUALITY FLAGS

12/17/2018
IDPS BLOCK 2.1 MX4
DR 8631: CRIS LUNAR INTRUSION DETECTION ALGORITHM
UPDATE AND PCT UPDATE

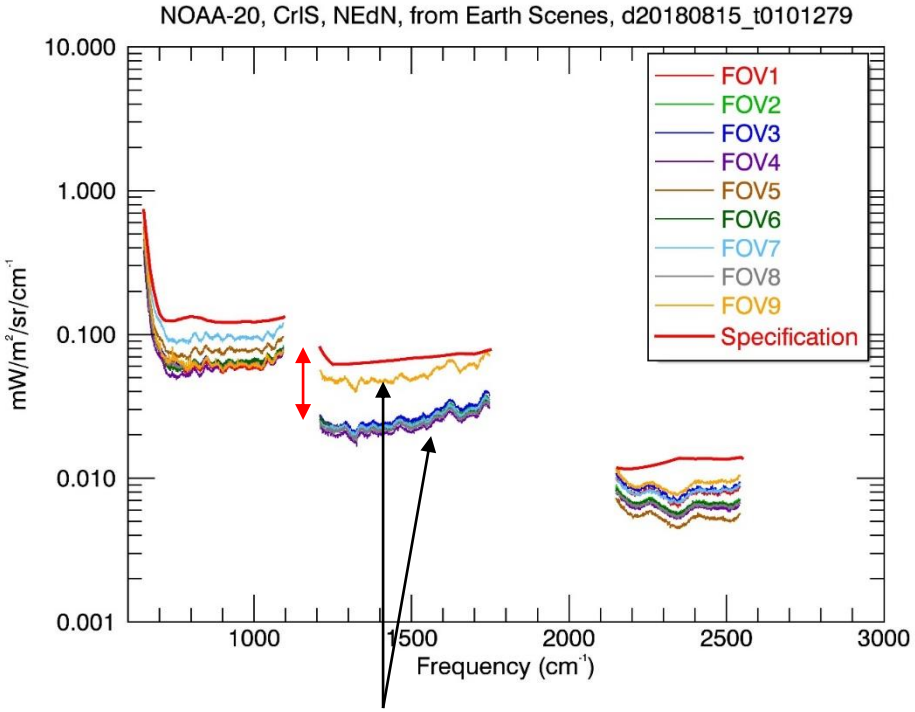
Provided by Yong Chen

NOAA-20 CrIS NEdN: After EP v115 Upload on Aug 14, 2018

NEdN on 8/13/2018 (EP v114)



NEdN on 8/15/2018 (EP v115) For Validated Maturity Level

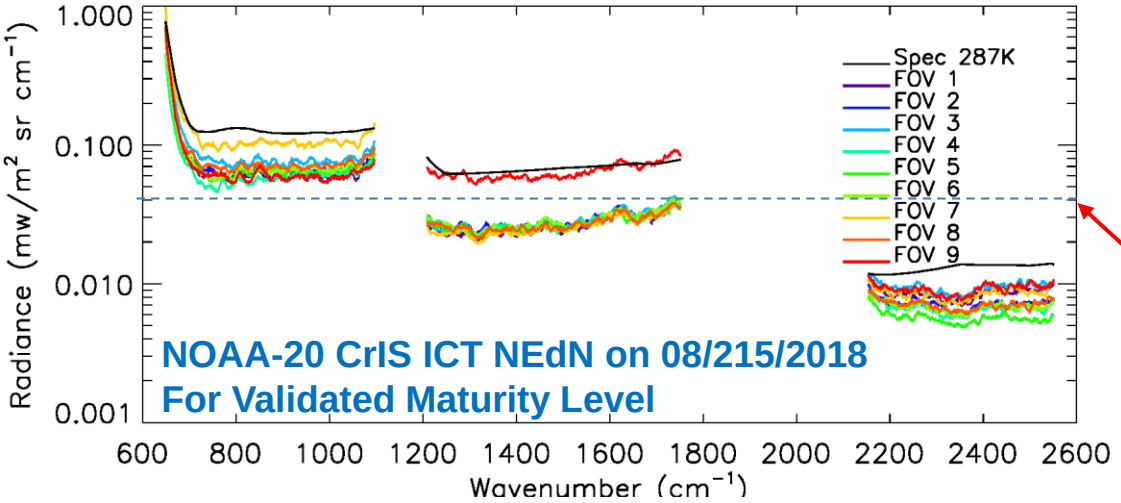


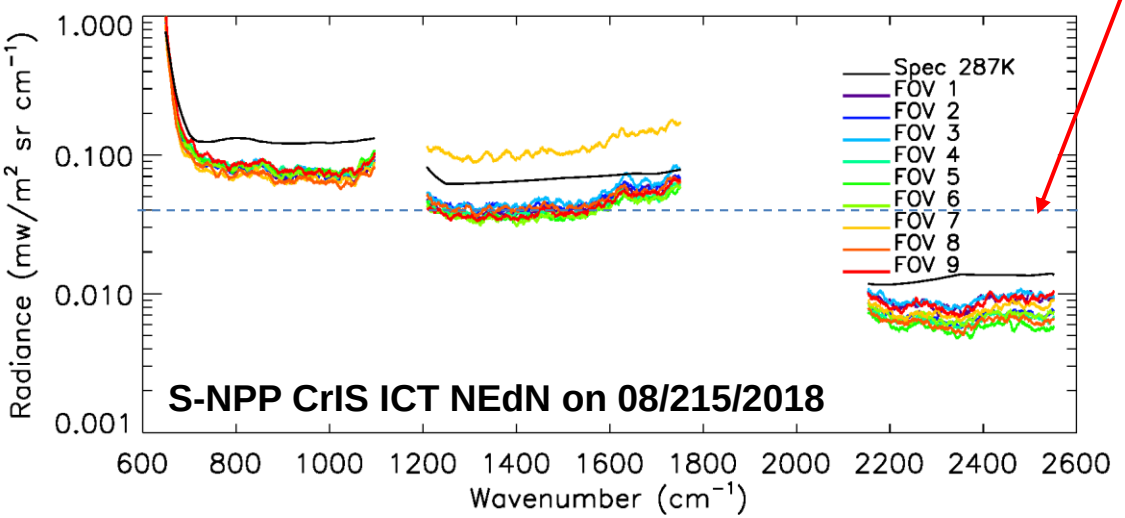
- MWIR NEdN has decreased ~15% due to PGA gain increase (FOV9 stays the same due to no gain change).
- All FOVs are below the specification.

Provided by Denis Tremblay

NEdN Performance: S-NPP vs NOAA-20

S-NPP and NOAA-20 are meeting the NEdN specifications (except NPP FOV7)





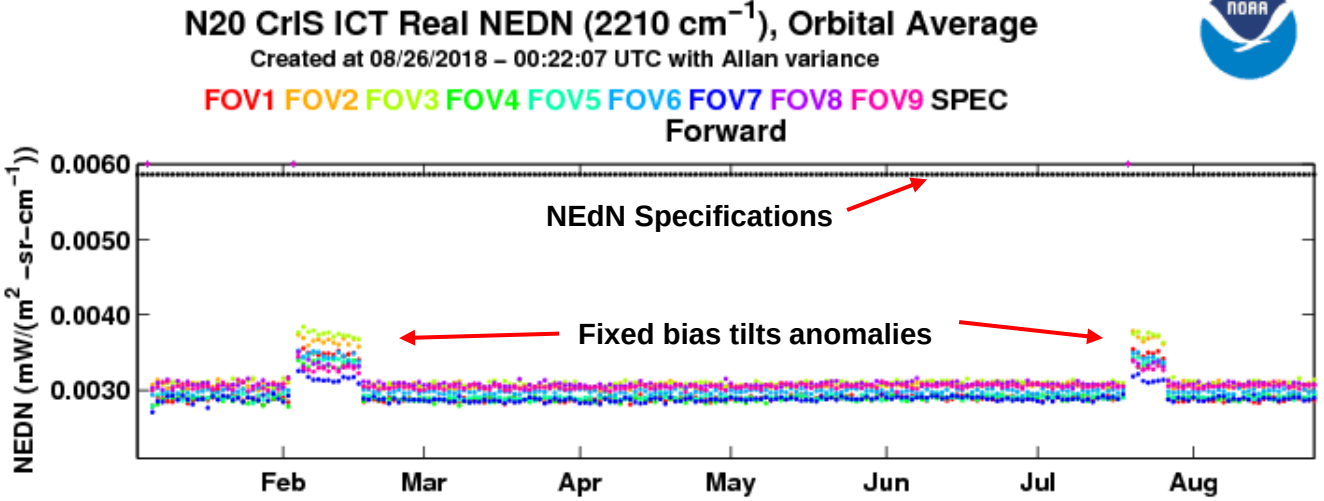
NOAA-20 CrIS MWIR NEdN shows better performance than S-NPP for FOVs 1-8

Provided by Yong Chen

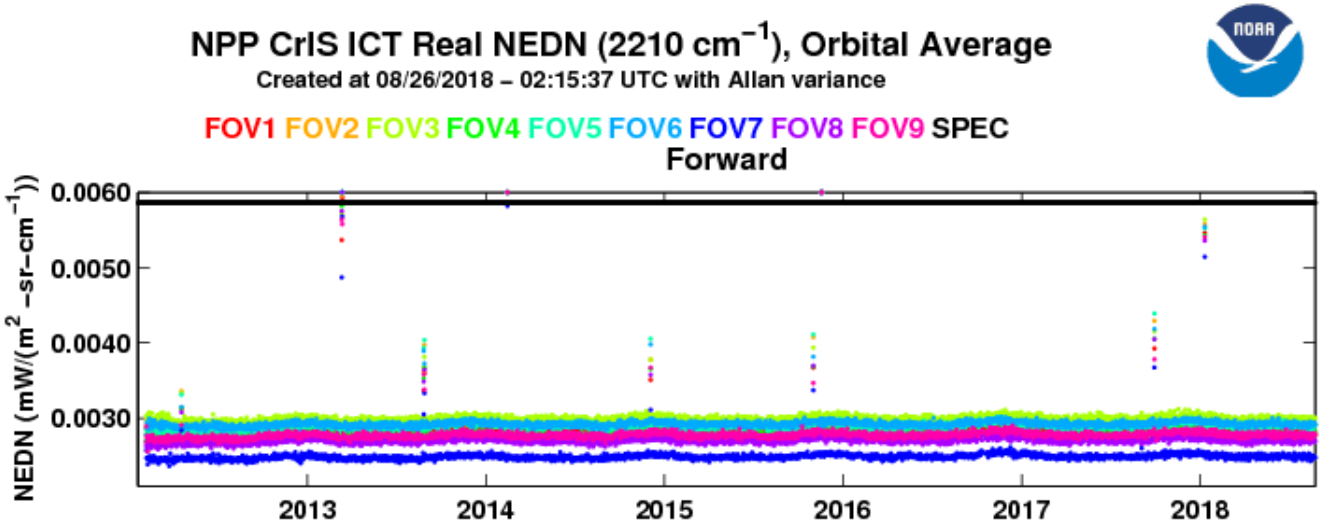
Noise Performance Trending: S-NPP and NOAA-20

NOAA-20

From STAR/ICVS



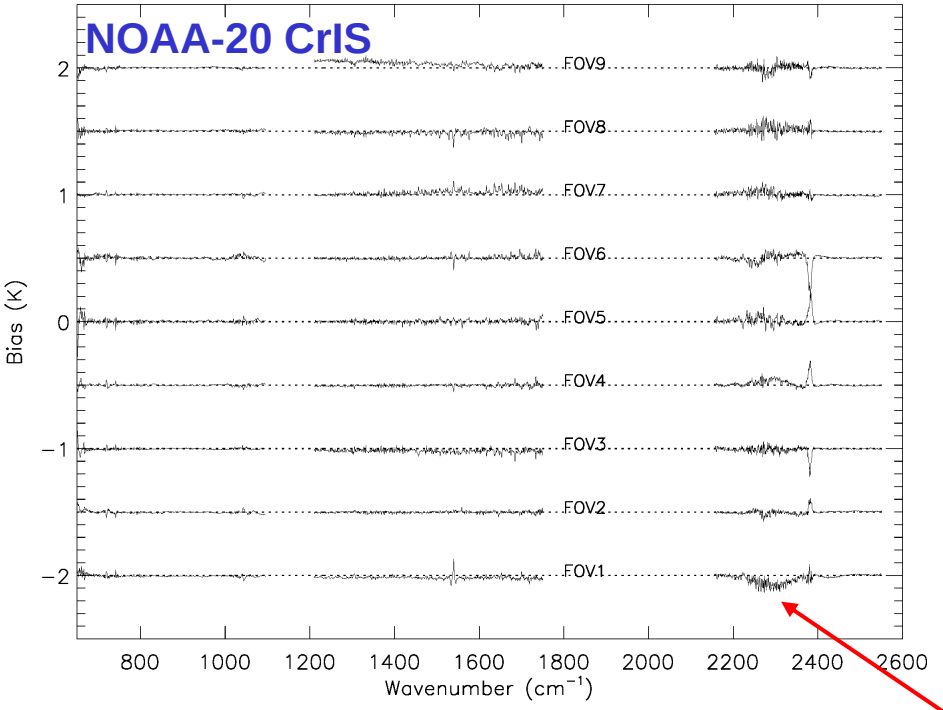
S-NPP

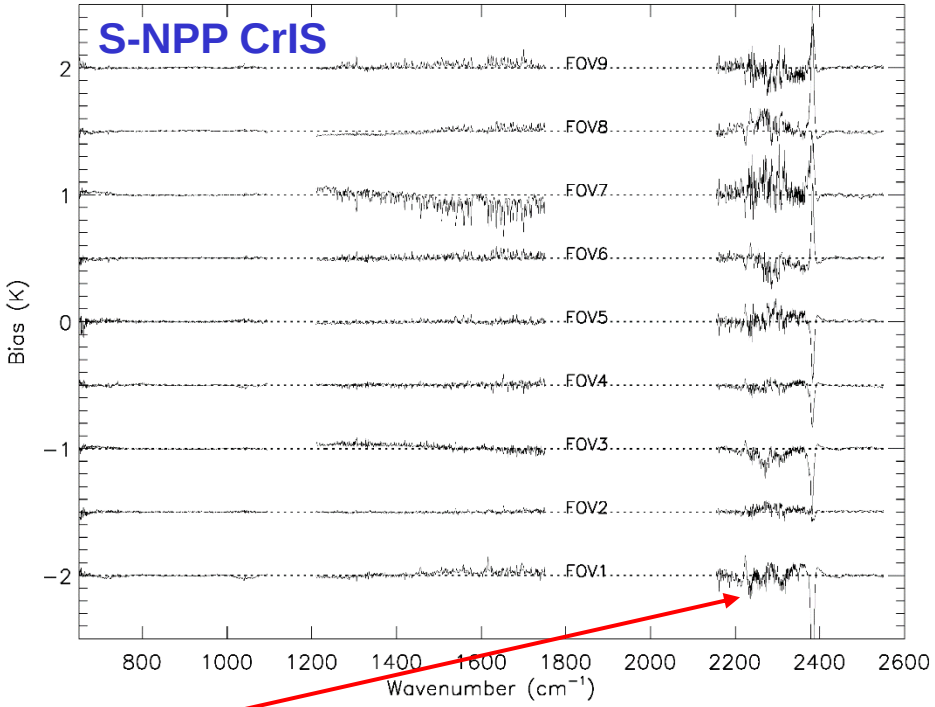


S-NPP and NOAA-20 are showing long term noise stability

FOV-to-FOV Radiometric Consistency

Mean Difference of Observed and Simulated (CRTM) Hamming Apodized Spectra (removed O-B bias for each FOV)





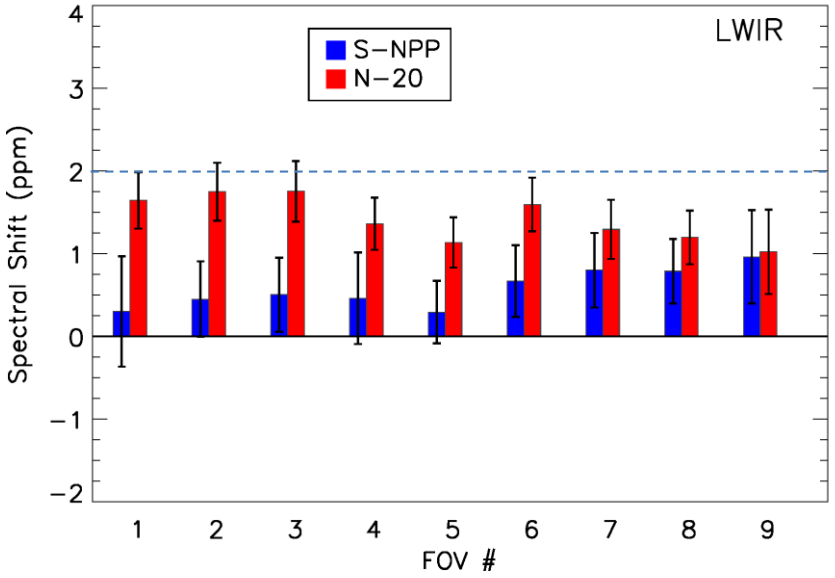
Over Clear-Sky/Ocean/No Sea Ice Surfaces

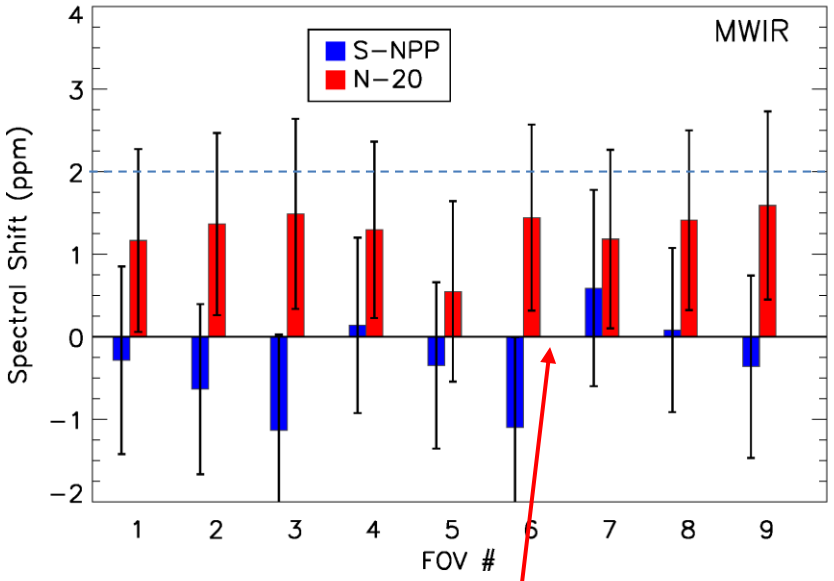
NOAA-20 shows better FOV2FOV Radiometric Consistency than SNPP for MW and SW bands mainly associate to better detectors linearity characteristics

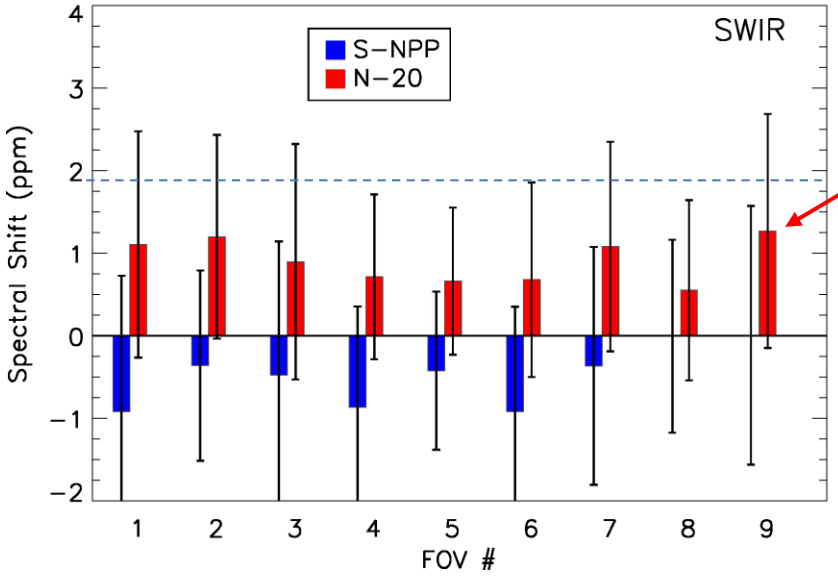
Uniformity of FOV-to-FOV radiometric and spectral performances allows the assimilation of all FOVs without special treatment for particular FOVs

Provided by Yong Chen

Absolute Spectral Accuracy: S-NPP and NOAA-20







S-NPP and NOAA-20 are ~5 times below the Spectral Uncertainty Requirement (10 ppm)

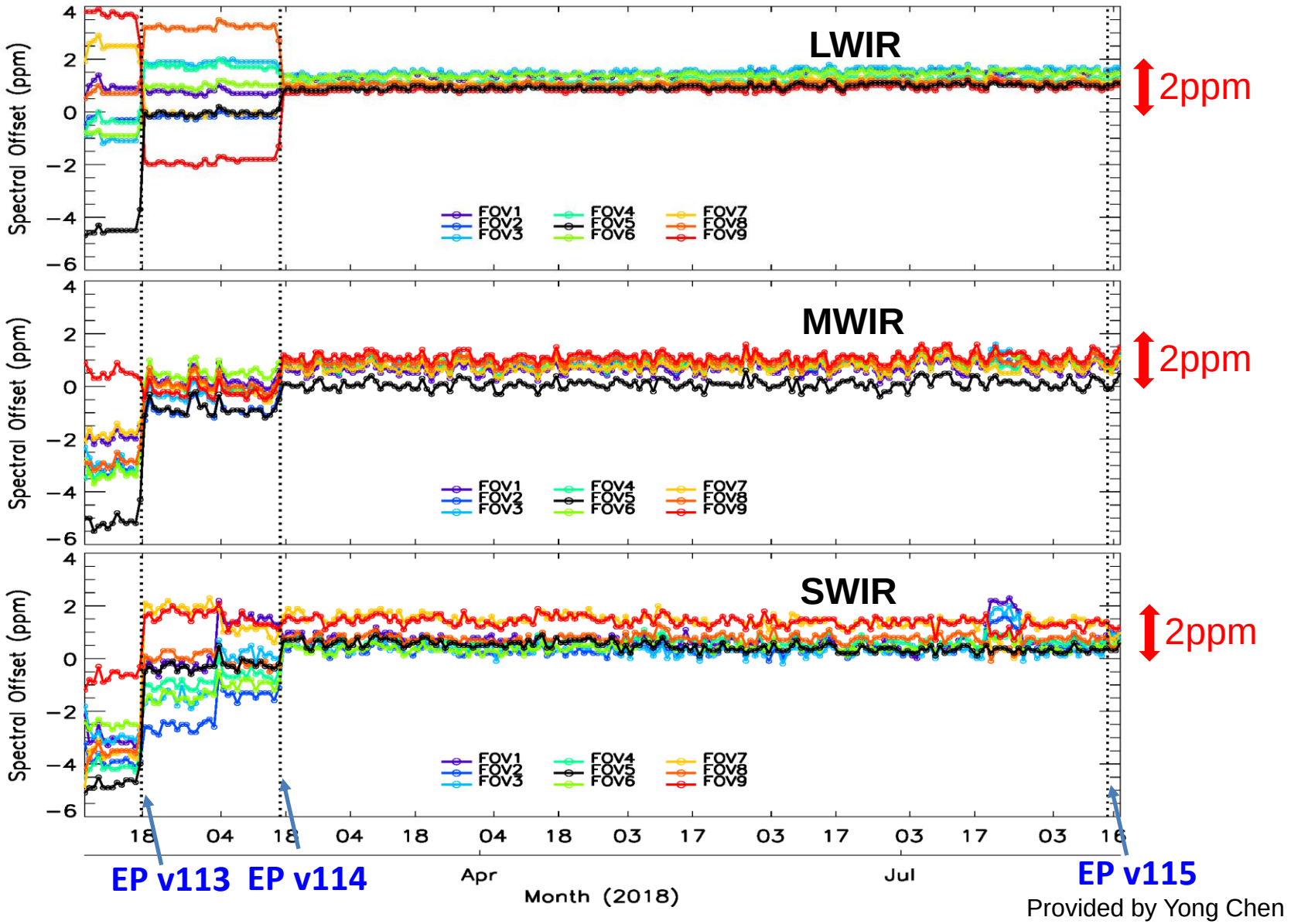
NOAA-20 shows similar performance over all FOVs and IR bands

SDR data from 08/17/2018

CRTM is used as reference.

Provided by Yong Chen

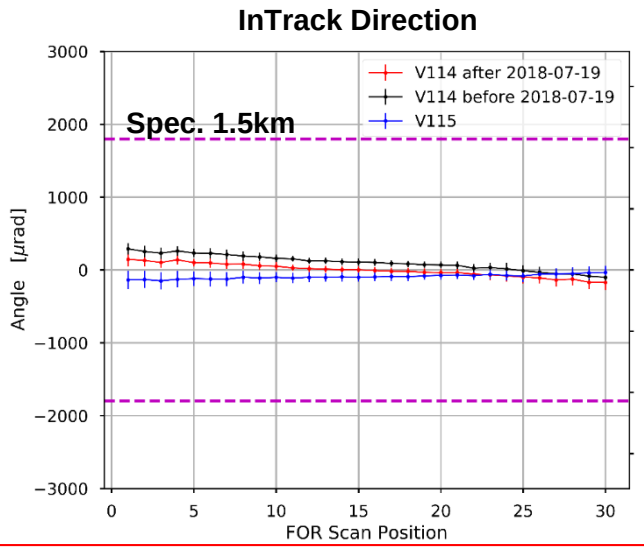
NOAA-20 Spectral Calibration: Absolute Accuracy Trending

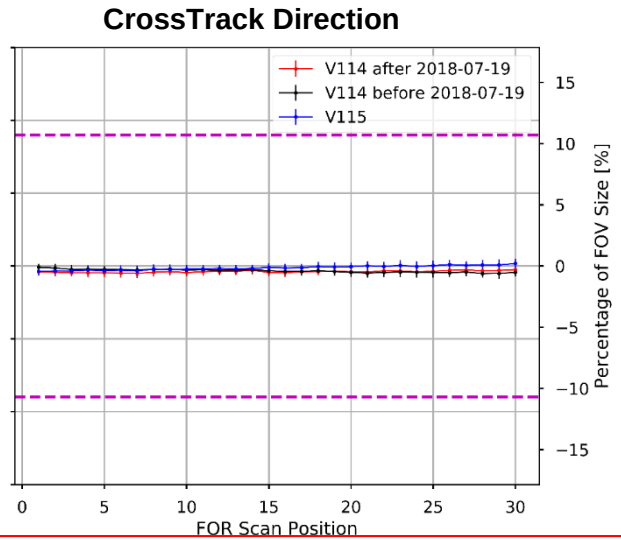


Provided by Yong Chen

Geolocation Uncertainty: S-NPP and NOAA-20

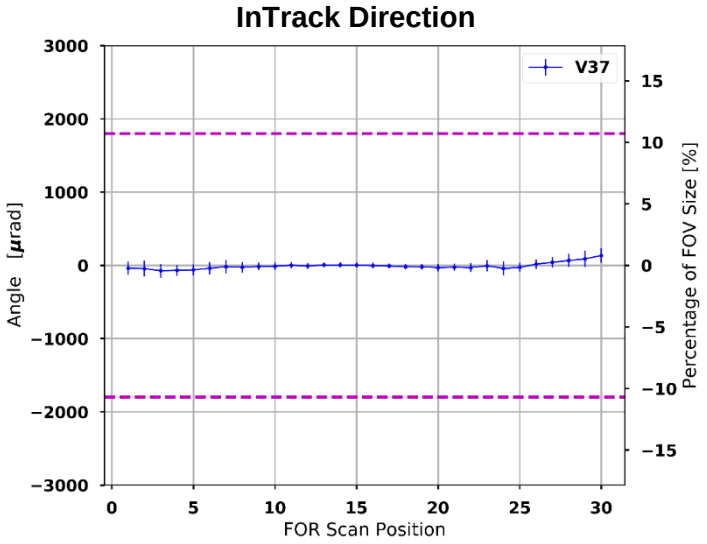
NOAA-20

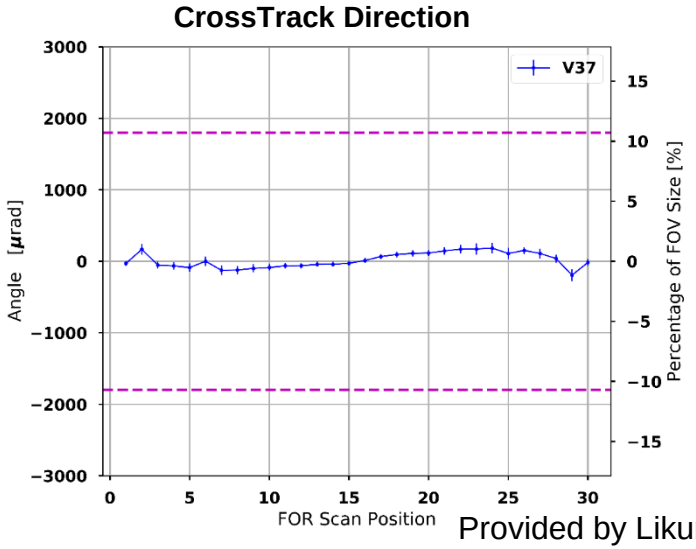




NOAA-20 shows better geolocation uncertainty due to an improvement performed in the method to derived the mapping angles defined in the engineering packet

S-NPP

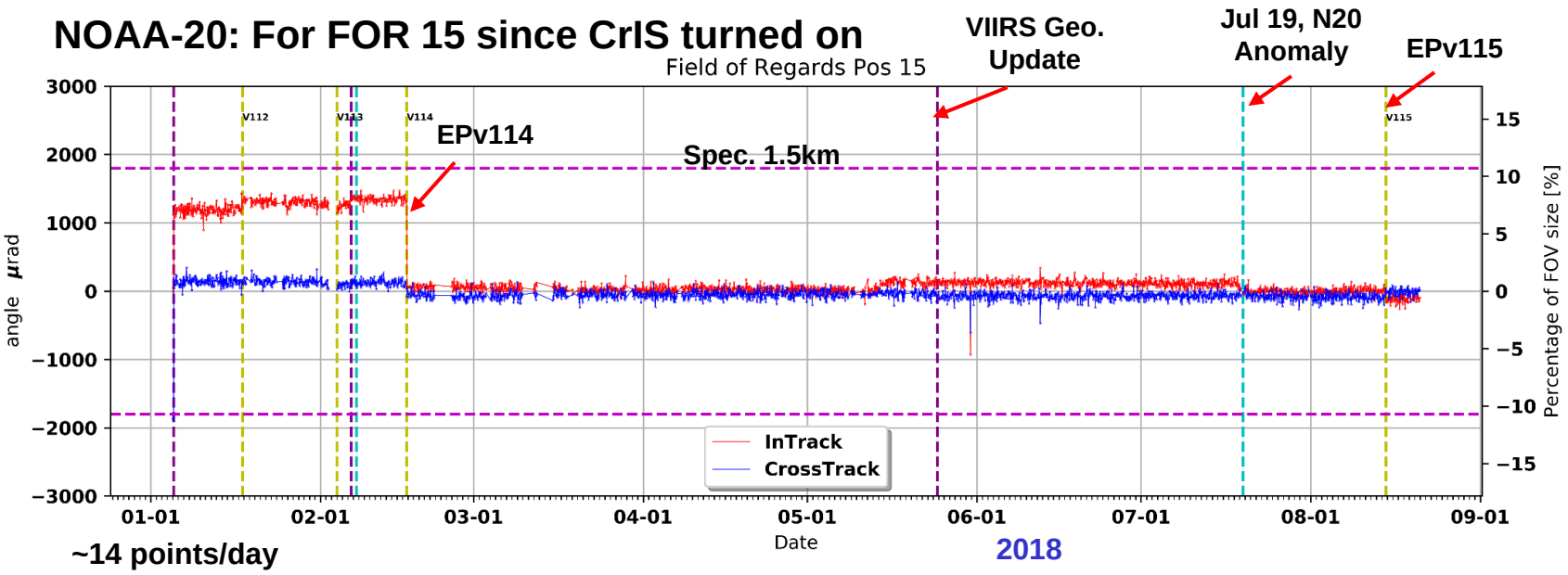




Provided by Likun Wang

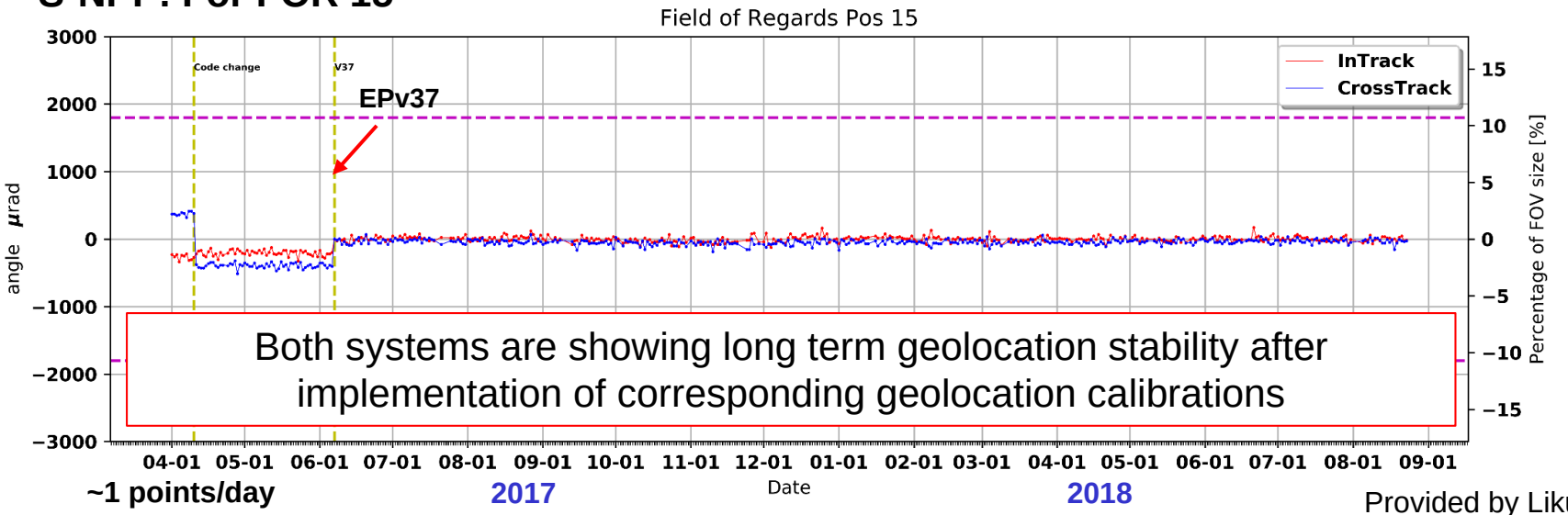
Geolocation Uncertainty Trending: S-NPP and NOAA-20

NOAA-20: For FOR 15 since CrIS turned on



~14 points/day

S-NPP: For FOR 15

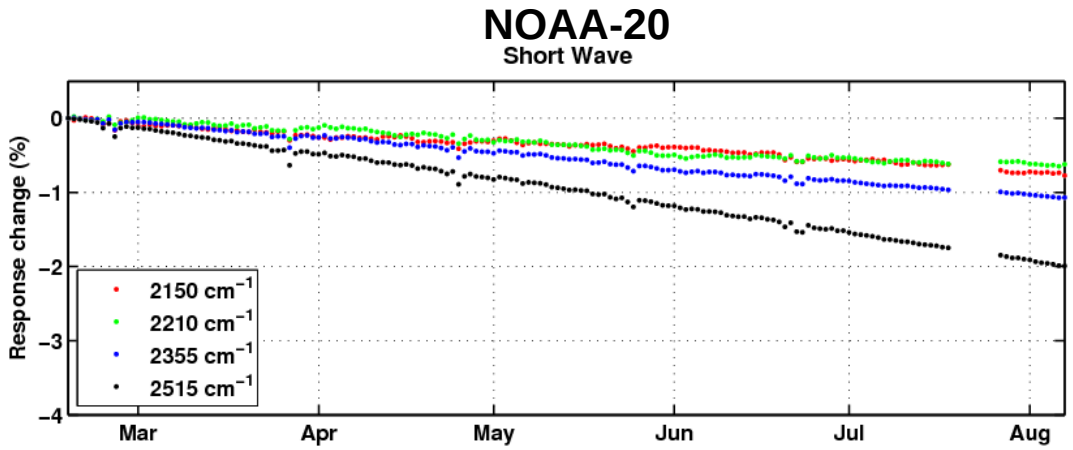


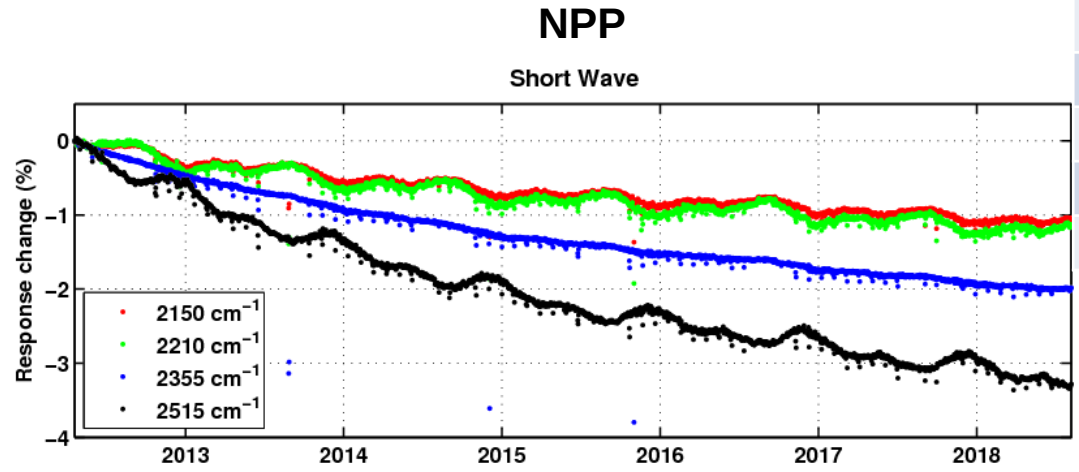
Both systems are showing long term geolocation stability after implementation of corresponding geolocation calibrations

~1 points/day

Provided by Likun Wang

CrIS Responsivity (Gain): S-NPP and NOAA-20





- These changes are calibrated out.
- Interesting to know if other NOAA-20 instruments are experiencing similar responsivity degradation.
- This could be related to contamination (molecular, particulate) of the optical surface.

Platform/ Band	Wavelength (cm $^{-1}$)	Degradation (%)	Time (months)
N20/SW	2515	-2%	6
NPP/SW	2515	-2%	26
N20 /MW	1710	-1%	3.5
NPP/MW	1710	-1%	54
N20 /LW	1050	-0.4%	6
NPP/LW	1050	-0.4%	24

- Recommend to monitor the responsivity performance.
- A gain change of 50% caused a 15% change in MW NEdN.
- An initial estimate of a 6% increase in NEdN could be expected in 5 years for SW.

From STAR/ICVS

CrIS SDR Performance: S-NPP and NOAA-20

NOAA-20 CrIS FSR SDR uncertainties (**blue**) vs. specifications (black)

Band	Spectral Range (cm^{-1})	Resolution (cm^{-1})	Number of Channels	NEdN* ($mW/m^2/sr/cm^{-1}$)	Frequency Uncertainty (ppm)	Geolocation Uncertainty** (km)
LWIR	650-1095	0.625	713	0.086 (0.14)	2 (10)	0.22 (1.5)
MWIR	1210-1750	0.625	865	0.0315 (0.084)	2 (10)	0.22 (1.5)
SWIR	2155-2550	0.625	633	0.00766 (0.014)	2 (10)	0.22 (1.5)

* Mean value averaged over 9 FOVs and over all band.
** Using worst case within 30^o scan angles.

S-NPP CrIS FSR SDR uncertainties (**blue**) vs. specifications (black)

Band	Spectral Range (cm^{-1})	Resolution (cm^{-1})	Number of Channels	NEdN ($mW/m^2/sr/cm^{-1}$)	Frequency Uncertainty (ppm)	Geolocation Uncertainty** (km)
LWIR	650-1095	0.625	713	0.101 (0.14)	2 (10)	0.25 (1.5)
MWIR	1210-1750	0.625	865	0.0522 (0.084)	2 (10)	0.25 (1.5)
SWIR	2155-2550	0.625	633	0.00741 (0.014)	2 (10)	0.25 (1.5)

CrIS SDR Team Milestones (FY18)

- Successfully achieved the NOAA-20 CrIS SDR products Beta, Provisional Maturity milestones, working toward reaching the *Validated Maturity Level*.
- Successfully and reliably produced NOAA-20 CrIS SDR products in both nominal and full spectral resolution in IDPS operational system.
- Made significant progress and delivered code for 1) Interferogram Spike Detection and Correction and 2) Lunar Intrusion Algorithm.
- Improved SDR calibration by using extended interferogram data points.
- Addressed all NOAA-20 and S-NPP CrIS anomaly events.
- Performed and discussed a trade study about reducing the CrIS field of view size from 14 km to 7 km.

CrIS SDR Team Future Plans and Improvements

- Implement a CrIS polarization correction algorithm.
- Prepare for the J2/CrIS TVAC activities.
- Implement future improvements in the CrIS SDR Calibration Algorithm and perform proper integration into the ADL Builder.
- Enhance the radiometric, spectral and geolocation validations of the S-NPP and NOAA-20 CrIS SDR.
  - The S-NPP CrIS is approaching 7-years of continued observations and requires performance monitoring.
- Support the STAR/ICVS to implement new and improved capabilities for the LTM of S-NPP/NOAA-20 CrIS.
- Look for new research activities and applications of the CrIS observations.

Users Feedback

Name	Organization	Application	User Feedback
Nick Nally	STAR	Soundings	**Positive Feedback** The similar performance found between the AVTP and AVMP EDR products of NUCAPS S-NPP and NOAA-20 is a testament to the comparable calibration accuracy of the CrIS and ATMS observations made by S-NPP and NOAA-20
Jim Jung/Andrew Collard	NCEP	NWP	**Positive Feedback** Initial quality of the CrIS data from NOAA-20 is comparable with that from NPP

Summary

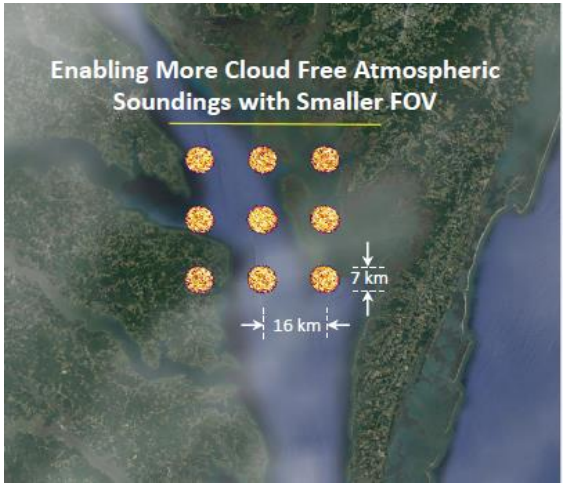
- The CrIS SDR Team has developed and demonstrated capabilities to support the Calibration, Validation and Monitoring of the S-NPP and NOAA-20 CrIS instruments, ensuring the quality of the CrIS SDR data.
- The NPP and NOAA-20 CrIS SDRs are meeting the requirements and are showing long term stability.
- No major risks have been identified for the NPP and NOAA-20 CrIS.
- Lessons learned from S-NPP have contribute to reach the Validated Level for NOAA-20 CrIS SDR in 7 months (3 times faster than S-NPP).
- The CrIS SDR Team is performing activities toward reaching Validated Maturity Level for NOAA-20 CrIS. Presented results show that NOAA-20 is meeting the requirements and is expecting August 14, 2018 as the effective date to achieved the Validate Maturity Level.
- The CrIS SDR Team is moving toward future higher spatial resolution IR hyperspertral observations by discussing the implementation of a 7 km CrIS FOV size for J4.

The CrIS SDR Side Meeting
August 28, 2017 from 9:00AM to 3:00PM

Time	Topic Title	Presenter
9:00-9:15	CrIS Polarization Corrections and Radiometric Uncertainty Estimates	Joe Taylor
9:15-9:30	NOAA-20 Satellite Intercalibration: CrIS/AIRS/IASI SNOs and CrIS/CrIS Double Difference Comparisons	Bob Knutson
9:30-9:45	NOAA20 a2 Progression and Summary of UW Efforts/Issues	David Tobin
9:45-10:00	Suggestions for New Research for the CrIS SDR Team	Larrabee Strow/Howard Motteler
10:00-10:15	Toward NOAA-20 CrIS SDR Validated Maturity Status: Radiometric and Spectral Performances	Yong Chen
10:15-10:30	*Break*	
10:30-10:45	Inter-Comparison of SNPP and NOAA-20 CrIS Toward Long-term Consistent Data Records	Likun Wang
10:45-11:00	Status of the J2/CrIS Pre-environmental TVAC Test	Lawrence Suwinski
11:00-11:15	Feedbacks from the NUCAPS Team on the Use of SNPP and NOAA-20 SDRs	Antonia Gambacorta
11:15-11:45	Study on Reducing the CrIS FOV Size from 14 km to 7 km for Implementation on J3 & J4	Joe Predina
11:45-12:00	Investigation of Noise Impact of 7km FOV on Nonlinearity Estimate from Diagnostic Mode Data	Dave Tobin
12:00-13:00	*Lunch*	
13:00-13:15	CrIS On-Orbit Noise and Relative Responsivity Trending from both SNPP and NOAA20	Kori Moore
13:15-3:00	*Open Discussion Session*	

Discussing the FOV size reduction for J4:

- **Small FOV approach shall be low risk, low cost for J4 implementation**
- **No optical design changes other than x2 field stop aperture reduction.**
- **Assess performance impacts associated with change.**
- **Cloud-free FOR Observations increases from 18% to 27%.**



Provided by Joe Predina